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THE LIFE-CYCLE AND TAXONOMIC RELATIONS OF *LINTONIUM VIBEX* (LINTON, 1900) STUNKARD AND NIGRELLI, 1930 (TREMATODA: FELLODISTOMIDAE)[1]

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Linton (1900) described *Distomum vibex* from the northern puffer, *Spheroides maculatus* (Bloch and Schneider), family Tetraodontidae, at Woods Hole, Massachusetts. The worms were from the pharynx, attached to the wall around the entrance to the ventral pouch. He noted that they resembled *Distomum fellis* Olsson, 1866, a species that was transferred to *Fellodistomum* Stafford, 1904 by Nicoll, (1909). Linton (1901) again reported *D. vibex* from *S. maculatus* and noted that the digestive tracts of the fishes contained small crabs, amphipods, both lamellibranch and univalve mollusks, annelids, seaweeds, and sand. This account of the food-habits was confirmed by Welsh and Breder (1922), who gave a detailed account of the life-history of *S. maculatus*, taken at Atlantic City, New Jersey. Linton (1905) reported *D. vibex* from *S. maculatus* at Beaufort, North Carolina; in this paper he described intestinal diverticula parallel to the pharynx, an error which he corrected later (1940). Linton (1910) described trematodes of fishes taken at Dry Tortugas, Florida in the summers of 1906, 1907 and 1908. It is significant that *S. maculatus* and *D. vibex* were not reported. In a review, Linton (1940) gave additional information concerning *D. vibex*, including the first and only report of the parasite in a host other than *S. maculatus*. The record of collections at Woods Hole, made primarily by Vinal N. Edwards, contains the entry (p. 42), "From oldwife, *Balistes vetula*, five, 8 September, 1903." It is the only report of infection in this host from the examinations of more than forty years. *Spheroides maculatus* is a southern species; its occurrence at Woods Hole is irregular and sporadic; it may not appear until midsummer and in 1915 Edwards recorded no *D. vibex* in the examination of 149 puffers between May and September, although in other years the incidence of infection reached 50% in July and August.

Stunkard and Nigrelli (1930) extended the description of *D. vibex*, corrected errors in Linton's accounts, and erected a new genus, *Lintonium*, for the species. The genus was assigned to the subfamily Fellodistominae Nicoll, 1909, family Fellodistomidae Nicoll, 1915; the history and naming of the family was discussed by Stunkard and Nigrelli and their decision was endorsed by Yamguti (1971, p. 69).

During June to October, 1938, 1939, and 1940, Nigrelli and Atz (1943) studied the biometry and parasites of *S. maculatus* in Sandy Hook Bay, New Jersey. They examined 294 fishes, 2 to 24 cm in length and reported on their protozoan, helminthic and crustacean parasites. Incidence of infection was correlated with date of collection, age, size, and sex of hosts. Infection with *L. vibex* increased with age of fishes and a total of 1003 specimens were taken. The authors predicated

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(p. 3), "*Lintonium vibex* appears to be species-specific. It has not been reported from any other fish occurring naturally in the North Atlantic." Referring to the report by Linton (1940) that *L. vibex* was found in *Balistes vetula,* they suggested that this was an accidental infection, acquired by a migrant in northern waters, since *L. vibex* had not been reported from this species in its natural habitat.

An attempt to discover the life-cycle of *L. vibex* was reported by Martin (1945). During the summer of 1938 and subsequent years he observed trichocercous, non-ocellate cercariae emerging from the bivalve mollusk, *Laevicardium mortoni.* They developed in elongate sporocysts in the haemocoelic spaces of the digestive gland. In the summer of 1940, students in the invertebrate course of the Marine Biological Laboratory found vermiform organisms in the jelly surrounding the infundibular portion of the digestive system of the ctenophore, *Mnemiopsis leidyi.* Martin recognized them as metacercariae and noted the resemblance to the cercariae from *L. mortoni.* He placed ctenophores in bowls of sea water with the cercariae. The larvae were carried into the digestive tract and moved to the infundibular region. Some shed their tails on entering the digestive tract, others on penetrating the jelly to become metacercariae, indistinguishable from those of natural infections. Martin noted that resemblance between the cercariae from *L. mortoni* and those from *Tapes decussatus,* described by Palombi (1934) as larvae of *Bacciger bacciger,* a fellodistomid species in the Mediterranean at Naples. In an attempt to infect *L. mortoni* with *L. vibex,* 21 clams which had not shed cercariae during a two-week isolation period were placed in an aquarium with eggs of *L. vibex* obtained by tearing gravid worms apart; 43 clams in another aquarium served as controls. After 23 days, a moribund experimental clam was found heavily infected with sporocysts, some containing cercariae identical with those shed by naturally infected clams. The remaining experimental clams were dissected 28 days after initial exposure to *L. vibex* eggs; one clam was infected, but with only young sporocysts containing germ balls. All the control clams were negative. Because of the inconclusive results, the experiment was repeated the next year but no infections were obtained. The larva from *L. mortoni* was described as a new species, *Cercaria laevicardium* Martin, 1945.

In the family Fellodistomidae, the first life-cycle, that of *Bacciger bacciger* (Rudolphi, 1819) Nicoll, 1914, was described by Palombi (1934). A more complete description and figure of the cercaria was given by Dolgikh (1968). The sporocysts and cercariae were found in *Chione gallica* (L. 1758) from the Black Sea. The second life-cycle in the family was reported by Chubrick (1952) for *Fellodistomum fellis.* The sporocyst and cercarial stages were found in *Nucula tenuis* in the Barents Sea. Its cercaria agrees with that of *B. bacciger* but the tail is brevifurcate and without setae, instead of non-bifid and setiferous as in *B. bacciger.* Later, Chubrick (1966) supplemented her account of the life-cycle of *F. fellis* and for *Fellodistomum furcigerum* described a cercaria so different from the larva of *F. fellis* that the identification probably is not correct.

In a consideration of cercarial structures, especially the correlation of trichocercous and furcocercous condition of tails with taxonomic relations, Cable (1954) gave a detailed description, with excellent figures, of the cercaria from *L. mortoni* which had been studied earlier by Martin (1945). The description was made from larvae obtained by dissection of clams and included the development of the excretory

system. The vesicle is V-shaped, in older cercariae the arms may extend to the level of the pharynx and contain concretions. The flame-cell formula is 2 [(3 + 3) + (3 + 3)]; a common stem extends through the length of the tail and there are two separate pores, interpreted as the relict remains of reduced furcae. Cable (1954) described the species as *Cercaria laevicardii*. The descriptions of Martin (1945) and Cable (1954) provide cardinal information on the asexual and developmental stages of the parasite in *L. mortoni*. There are successive generations of sporocysts and the cercariae emerge from the clams during both day and night. The cercaria is a tricocercous larva in which the caudal setae are arranged in fused bundles, aligned dorso-ventrally, and disposed on opposite sides of the tail, like banks of oars. These structures were described and figured by Cable (1954) as "lateral finlets." The larvae swim for about 12 hours, exhibit no photactic response, and when older may attach to the bottom of a container by the tips of their tails.

Materials and Methods

While investigating the life-cycle of *Neopechona pyriforme* (*q.v.*, Stunkard, 1969), specimens of *Mnemiopsis leidyi* were found to harbor natural infections with two different types of metacercariae: those of *N. opechona* located at the bases of the combs, and those described by Martin (1945), scattered about in the dense jelly around the infundibular portion of the digestive tract. To pursue the suggestion of Martin that *C. laevicardium* may be the larval stage of *L. vibex*, life-history experiments have been conducted as material became available.

During the summer of 1968, 246 specimens of *L. mortoni* were examined; they were collected at Waquoit, Quissett, and North Falmouth. Infections were common in clams from all three areas, and in certain collections about one-half of the specimens were infected, although after three or four weeks many of them had not liberated cercariae and infection was discovered on dissection of the clams. It is clear that under laboratory conditions, infections may be retarded or remain latent, perhaps because of inanition of the host. Specimens of *M. leidyi* were taken from the same areas as the infected clams and some were heavily infected with metacercariae of both *C. laevicardium* and *N. pyriforme*. Martin (1945, p. 206) observed, "Naturally infected *M. leidyi* had varying degrees of infection. Those collected from the Eel Pond had either very few, generally not over four, or were uninfected, while those collected from Menaunt exhibited almost 97 per cent infection, some of the infections being very heavy. The number of metacercariae per ctenophore varied in this group from 3 to well over 100."

Results

Study of the life-cycle of *L. vibex* has been continued since 1968. In former years, 1965 to 1968, puffers, *S. maculatus*, were common at Woods Hole, but in recent years the species has been rare and in certain summers none were taken until August, when a few young of the year appeared. During this period developmental stages were studied, and sketches of juvenile worms are reproduced in Figures 3 and 4. When large puffers were available as a source of worms, attempts were made to infect *L. mortoni*. Eggs were collected by placing gravid worms in small dishes of sea water for 24 hours, when those in the terminal part of the uterus


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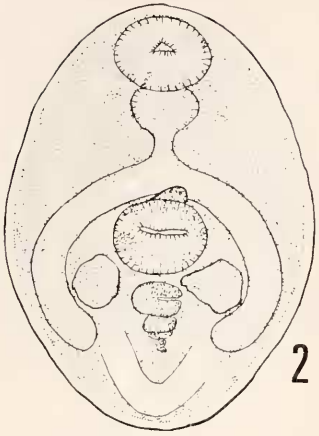
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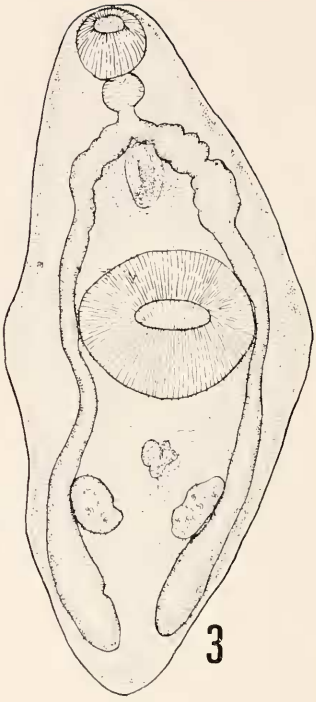
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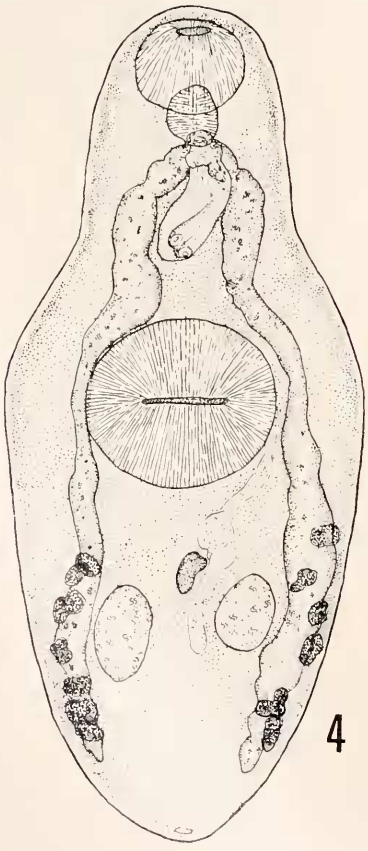
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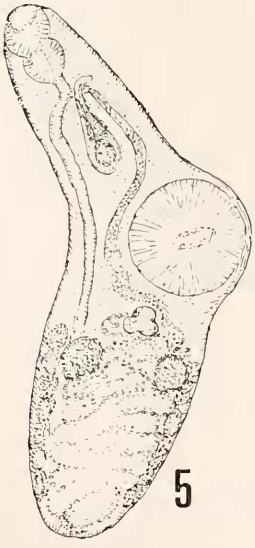
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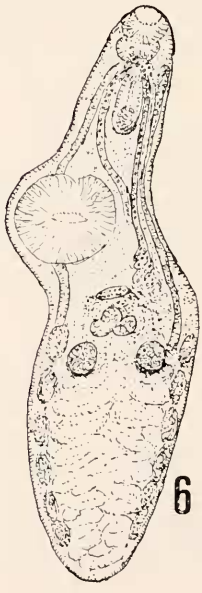
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were extruded. The eggs, (Fig. 1) measure 0.052 to 0.055 by 0.031 to 0.032 mm, have heavy yellow shells, and an operculum at the narrower end. Eggs in sea water are covered by an adhesive substance and stick to instruments, pipets, to vegetation and the bottom of a dish. Eggs from the end of the uterus appear to be embryonated, but the miracidia are motionless, except for rare and slight twitching, and hatching has never been observed. Eggs have been maintained for three weeks at summer temperature with no change in the appearance of the larvae and with no emergence. Attempts to infect *L. mortoni* by dropping eggs in the incurrent siphon were not successful and when eggs were inserted in the mantle cavity, a few shells with open opercula were found in the feces but no infections were obtained. To simulate natural conditions, clams were implanted in mud and sand in a tray, covered with a coarse wire screen and placed on the bottom of a tank that contained four large puffers. At the end of the summer, the clams were dissected with only negative results.

When attempts to infect clams proved futile, investigation turned to the infection of fishes. Maintenance of puffers in the laboratory is easy; they feed avidly and come to the surface to grab food from a pair of tweezers. To conduct infection experiments with larger fishes, it is essential to keep them for some time, preferably several weeks, to permit natural infections to mature. After feeding metacercariae, it is requisite that hosts be dissected at regular intervals to trace development of the worms and establish identity of the specimens. Scarcity of fishes prevented this type of research in some summers and recourse was taken to infection of small fishes, the young of the year. In some years they appeared early in July and in others not until the middle of August. At this time they are about 2.5 cm long and may have juvenile specimens of *Podocotyle atomon* or *Monorchcides cumingiae* in their intestines, acquired by eating *Gammarus* sp. or small bivalves that harbor the metacercariae of these species. But natural infection by *L. vibex* has never been found in these young puffers. Indeed, the ctenophores, *M. leidyi,* ordinarily do not appear in the Woods Hole area before the middle of July and sometimes not until August. When the ctenophores appear, they already harbor metacercariae of *C. laevicardium.* The young puffers appear at about the same time. They readily ingested bits of *Mytilus edulis* in which metacercariae had been implanted. In 1968 a small puffer fed metacercariae on August 2, was dissected on August 25 and a small trematode (Fig. 2) was found in the pharynx. Fixed, stained and mounted, it is 0.18 mm long, 0.11 mm wide and the oral sucker is 0.036 mm in diameter. Another fish, fed at the same time, was dissected on August 31; it contained 12

FIGURE 1. *Lintonium vibex,* egg, in sea water after three weeks at summer temperature, Woods Hole.

FIGURE 2. *L. vibex,* young worm, after three weeks in the pharynx of a young puffer of the year; taken August 25, 1968; fixed, stained and mounted, somewhat contracted, 0.18 mm long.

FIGURE 3. *L. vibex,* juvenile, natural infection, taken June 22, 1973; fixed, stained and mounted, 1.8 mm long.

FIGURE 4. *L. vibex,* juvenile, natural infection, taken June 22, 1973; fixed, stained and mounted, 2.60 mm long.

FIGURE 5. *Lintonium hetrorchis* (Bilquees, 1972) Madhavi, 1975, paratype specimen, from the U. S. National Museum, 7.2 mm long.

FIGURE 6. *Lintonium isorchis* (Bilquees, 1972) Madhavi, 1975, paratype specimen, from U. S. National Museum, 8.82 m long.

juvenile *L. vibex*. When alive, the worms were larger than when fixed, stained and mounted. In 1977, the ctenophores did not arrive until August and the feeding experiments were continued. The experiment was terminated the middle of September when the fishes were about 6 cm long. Young worms, about twice as large as the metacercariae, were recovered. The recovery of juvenile worms, three to four weeks after feeding of metacercariae, supports the postulate that *C. laevicardium* is the larva of *L. vibex*.

Discussion

The systematic relations of *L. vibex* are involved, confused, and uncertain. A review of the literature discloses the situation. Johnston (1913) described *Steringotrema pulchrum* from *Tetraodon hispidus* taken in Queensland, Australia. He noted (p. 389), "While I place this species in Odhner's genus *Steringotrema,* it appears to be more related to *Distomum vibex* Linton than to any of the three species enumerated by Odhner. *D. vibex* evidently belongs to the same genus." Odhner (1928) declared that *S. pulchrum* Johnston is identical with *Gastris consors* Lühe, 1906, a parasite of *Tetraodon stellatus* from the Pearl Banks of Ceylon, Indian Ocean. Layman (1930) reported specimens from *Cantherines modestus* taken in Peter-the-Great Bay, a portion of the Sea of Japan, and assigned them to *S. pulchrum* Johnston, 1913. Yamaguti (1934) identified specimens from *Monacantus cirrhifer* taken in Toyama Bay, Sea of Japan, and *Alutera monoceros* (= *Cantherines unicornu* Basilewsky) from the Pacific coast of Japan as *Distomum vibex* Linton, 1900. He noted the similarity with *S. pulchrum* Johnston, 1913 and suggested that the American, Australian and Japanese species of *Lintonium* may be conspecific. Although Yamaguti (1934) recognized the species, *pulchrum,* as a member of *Lintonium,* the new combination *Lintonium pulchrum* (Johnston, 1913) was made by Yamaguti (1954).

Crowcroft (1950) described specimens from the gullet of *Cantherines setosus* and *Cantherines güntheri* taken in southern Tasmania as *Lintonium vibex*. A cotype specimen of *C. pulchrum* from the Australian Museum was described as *Lintonium consors* and represented in Figure 2. It is very similar to *L. vibex;* the only difference is in the disposition of the vitellaria, and the figure might have been made from a specimen of *L. vibex* taken at Woods Hole. Crowcroft did not examine specimens of *Gastris consors* but the figure by Lühe (1906) was reproduced as Figure 1. Despite the enormous differences between the figures of *S. pulchrum* and *G. consors,* Crowcroft accepted the claim of Odhner on the identity of the two species. The name *Gastris* Lühe, 1906 was preoccupied and Crowcroft suggested the new combination, *Lintonium consors* (Lühe, 1906). He observed that *G. consors* and *S. pulchrum,* regarded as identical, are from warm waters of Ceylon and Australia and like *L. vibex* occur in fishes of the family Tetraodontidae, whereas the parasites from hosts in Japan, Peter-the-Great Bay and Tasmania occur in fishes of the family Balistidae that live in cool water. Crowcroft stated (p. 317), "it might be argued, however, that the forms most closely related to *L. vibex* from the Woods Hole region are those reported by Yamaguti (1934), Layman (1930), and in the present paper. These forms, which all occur in cool waters, are identified with *L. vibex* simply because the recorded differences, using

our present criteria, are not sufficient to justify specific differentiation." Yamaguti (1954) gave a generic diagnosis of *Lintonium* Stunkard and Nigrelli, 1930 (syn. *Gastris* Lühe, 1906, *nec Gastris* Billberg, 1820), and listed three valid species: *L. vibex* (Linton, 1900) Stunkard and Nigrelli, 1930; *L. consors* (Lühe, 1906) Crowcroft, 1950; and *L. pulchrum* (Johnston, 1913) new combination.

Skrjabin and Koval (1957) recognized four valid species in the genus *Lintonium,* the three listed by Yamaguti and *Lintonium laymani* n. sp., a new designation for *Steringotrema pulchrum* of Layman (1930).

Winter (1958) redescribed and figured *L. vibex* from *Spheroides lobatus,* taken in the Bahia de los Muertos, Golfo de California, Baja California Sur, México. This report gave records of host and locality and the description extended the limits of variation in the species. Winter stated (p. 179), "Debe tenerse en cuenta que Skrjabin y Koval (1957) registraron cuatro especies válidas para el género *Lintonium: L. consors, L. vibex. L. pulchrum* y *L. laymani,* la última de las cuales ha sido llamada por el "*Steringotrema pulchrum*" de Layman (1930). Sólo las dos primeras de estas son consideradas válidas por el autor; la tercera y cuarta especies se consideran como sinónimos, de acuerdo con Crowcroft (1950). La distribución de las dos especies del género *Lintonium,* exclusivamente de peces plectognatos en las familias estrechamente relacionadas Balistidae y Tetraodontidae, es algo interesante. *Lintonium vibex* has sido reportado de ambas familias en el Atlántico Norte templado de América, de un huésped tetraódontido en el Pacífico oriental tropical de México (Golfo de California), y de la familia Balistidae en aguas templadas y de transición alrededor de Japon y en al mar de Tasmania. *Lintonium consors* es conocida solemente de la familia Tetraodontidae en las aguas cálidas de Ceilán y Queensland, Australia."

Manter and Pritchard (1962) redescribed *L. consors* on specimens from *Arothron hispidus* (syn. *Tetraodon hispidus*) in Hawaii. The worms were large 15 to 16.6 mm long and 4.3 to 5.7 mm wide. They declared (p. 115), *L. pulchrum* "is distinguished from *L. consors* by its smaller size, a hindbody about half the total length, a more posterior acetabulum, the ovary almost immediately posterior to the acetabulum, and eggs 43–48 by 32–35 μ." Further, they predicated that the specimens from *Cantherines setosus* and *C. güntheri* taken in Tasmania by Crowcroft are not *L. vibex.* The worms were regarded as specifically identical with those from *Cantherines modestus* taken in Peter-the-Great Bay and described by Layman (1930) as *Steringotrema pulchrum.* These specimens, together with those from *Cantherines unicornu* and *Monacanthus cirrhifer* assigned to *L. vibex* by Yamaguti (1934) were recognized as *Lintonium laymani* Skrjabin and Koval, 1957.

Oshmarin (1965) described and illustrated (Fig. 16), nine specimens taken October 10, 1960 from *Alutera monoceros* on the coast of North Vietnam. The worms were assigned to *Lintonium vibex.* I am indebted to Dr. B. Lebedev of the Far-Eastern Center, USSR Academy of Sciences, Vladivostok, for a reprint of the paper by Oshmarin and to the Misses Nina Root and Mildred Bobrovich of the library staff of the American Museum for an English translation of the report. The measurements of the worms agree substantially with those given by Layman (1930) and Yamaguti (1934) for worms from the same host species in the Sea of Japan, and specific identity is apparent.

Machida (1971) reported on fellodistomid trematodes from *Navodon modestus* (= *Cantherines modestus*) and *Stephanolepis cirrhifer* (= *Monacanthus cirrhifer*) from the Toushima Islands in the Sea of Japan, regarded as identical with worms from the same hosts by Layman (1930) and Lamaguti (1934). He observed (p. 190), "As Yamaguti (1934) pointed out, *vibex* and *pulchrum* resemble each other and it is very probable that they belong to one species. This applies to *laymani;* the dimensions of *laymani* with comparisons to those of the present specimens of *vibex* are shown in Table 3. There seems to be little difference between the two, and the slight differences fall within the limits of variation of *vibex*. According to the key given by Skrjabin and Koval (1957), the acetabulum is situated equatorial in *laymani* whereas it is in the anterior half of the body in *vibex*. However, the examination of the present specimens demonstrated that the situation of the acetabulum is variable so that it makes no distinction between the two. The arrangement and shape of the other organs resemble each other. Of *Lintonium* species, at least *laymani* is considered to be placed in synonymy with vibex." The report by Machida confirms the idea that the specimens described by Yamaguti (1934) are specifically identical with those of Layman, but does not establish their identity with *L. vibex*.

Bilquees (1972) erected a new genus, *Paradiplobulbus,* to contain two new species from *Tetraodon lunaris*, family Tetraodontidae, taken on the Karachi coast of West Pakistan and described as *Paradiplobulbus hetrorchis* and *Paradiplobulbus isorchis*. Madhavi (1975) reviewed the report by Bilquees and predicated (p. 270), "The genus *Paradiplobulbus Bilquees*, 1972 very closely resembles *Lintonium* from which it was not differentiated." . . . "Here it is regarded as a synonym of *Lintonium* and the two species *P. isorchis* Bilquees, 1972 and *P. heterorchis* Bilquees, 1972 from *Tetraodon lunaris* from the coast of Karachi hence become *L. isorchis* (Bilquees, 1972) n. comb. and *L. heterorchis* (Bilquees, 1972) n. comb. respectively. Another genus that seems to be identical to *Lintonium* is *Paradiplangus* Gupta, 1968. It agrees in all details with *Lintonium* except for the I-shaped excretory bladder. The two species, *P. tetradontis* Gupta, 1968 and *P. indicus* Gupta, 1968 from *Tetraodon viridipunctatus* in Madras (Bay of Bengal) agree in many respects with *L. pulchrum* collected by me from *Gastrophysus lunaris*. Additional specimens of *P. tetradontis* and *P. indicus* may well show that they are synonymous with *L. pulchrum*."

Madhavi (1975) described ten species of fellodistomid trematodes, four of them new, from marine fishes of the Waltair coast, Bay of Bengal. He identified as *Lintonium pulchrum* (Johnston, 1913) 12 specimens found in one of 21 green, rough-backed globe fish, *Gastrophysus lunaris* (Bleeker). According to Dr. James Atz, of the American Museum, the host is *Lagocephalus lunaris* (Bloch and Schneider), family Tetraodontidae. The description was brief, cursory, and added nothing to knowledge of the species. Madhavi also described *Lintonium pseudovibex* n. sp. from three specimens found in the pig-faced leather-jacket, *Monacanthus choirocephalus,* family Balistidae. Madhavi accepted the criteria proposed by Manter and Pritchard (1962) to distinguish between *L. vibex* and *L. laymani* and observed (p. 269), "*L. pseudovibex* shows characteristics that are intermediate between *L. vibex* and *L. laymani*. The sucker-ratio approaches that of *L. laymani* almost as closely as that of *L. vibex* and the egg-size falls within the limits for

L. laymani." There appear good reasons for regarding *L. pseudovibex* as a synonym of *L. laymani.*

A further complication was introduced by the statement of Madhavi (p. 270), "A combination of sucker-ratio and egg-size similar to that in *L. pseudovibex* also occurs in specimens of *L. vibex* reported by Parukhin and Chikunova (1964) from *Abalistes stellaris* from South China Sea. Hence they are regarded as *L. pseudovibex* n. sp." I have not been able to obtain a copy of the paper by Parukhin and Chikunova, but if the specimens they identified as *L. vibex* are identical with *L. pseudovibex,* they may be *L. laymani.*

The genus *Paradiplobulbus* Bilquees, 1972 was suppressed as a synonym of *Lintonium* by Madhavi (1975). Originally, the genus was included in the family Allocreadiidae and compared only with *Diplobulbus* Yamaguti, 1934 (Fellodistomidae); *Labrifer* Yamaguti, 1936 (Lepocreadiidae); and *Brevicreadium* Manter, 1954 (Zoogonidae). The type and paratype specimens were deposited in the Helminthological Collection of the U. S. National Museum, and through the kindness of Dr. J. Ralph Lichtenfels, I have studied paratypes of both species. The paratype of *P. hetrorchis* is shown in Figure 5. The specimen is 7.2 mm long with the following measurements: acetabulum, 1.25 mm; oral sucker, 0.45 mm; pharynx, 0.40 mm; ovary, 0.33 mm; testis 0.40 by 0.47 mm; eggs, average 45 by 32 μ. Figure 6 is of the paratype specimen of *P. isorchis.* It is the one mentioned by Bilquees (p. 252) and shown in his Figures 13 and 14, as atypical in the shape and location of the testes and with an extracecal uterine coil in the preacetalular region, which partially overlies the pharynx. In this specimen, eggs have been extruded from the uterus into the tissues and the preacetabular uterine coil suggests that the worm had been subjected to temporary pressure before fixation. In Bilquees' Figure 13, the structure labelled as RS is not a seminal receptacle; it is an early uterine coil which contains spherical, thin-shelled eggs and in which the embryos are heavily stained. The specimen is 8.2 mm long, with the following measurements: acetabulum, 1.35 mm; oral sucker, 0.52 mm; pharynx, 0.45 mm; ovary, 0.38 mm; testis, 0.60 mm; eggs, average, 48 by 32 μ. The opinion of Madhavi is accepted; the worms belong to the genus *Lintonium,* and although very similar, may be distinct. Whether or not they are identical with *L. pulchrum* is uncertain.

As noted earlier, Madhavi (1975) also suppressed *Paradiplangus* Gupta, 1968 as a synonym of *Lintonium* and predicated that the two species, *Paradiplangus tetradontis* and *Paradiplangus indicus* may be identical with *L. pulchrum.* It is significant that Madhavi did not cite a reference to the publication by Gupta (1968) on the new genus *Paradiplangus* with the new species, *P. tetradontis* and *P. indicus.* The description of *Paradiplangus indicus* sp. nov. was published in the *Riv. Parassitol.,* 29: 17–20, (1968), and the references in that paper include the entry, "Gupta, A. N. (1968): Studies on a new genus *Paradiplangus* and a new species *P. tetradontis* (Trematoda-Digenea) from *Tetradon viridipunctatus* (Günther) from Puri, India. *Rev. Biol. Trop. Costa Rica* (in press)." An examination of the *Rev. Biol. Trop. Costa Rica* for the period 1967–1974 did not disclose the reported publication and it appears certain that the genus was not described there. No other information is available here. *Paradiplangus indicus* was based on two specimens, recovered from the dissection of 20 *T. viridipunctatus.* The description is brief and

Figure 1 is of a distorted, contracted, flattened worm, that provides little specific information. The excretory vesicle was described as tubular, which, if correct, would exclude the species from the family Fellodistomidae. Indeed, Gupta included the genus *Paradiplangus* in the family Callodistomidae.

Yamaguti (1971) accepted *L. vibex* (Linton, 1900); *L. consors* (Lühe, 1906); *L. pulchrum* (Johnston, 1913); and *L. laymani* as valid species. He stated that *L. novikovi* Baeva, 1965 does not belong in *Lintonium,* but made no allocation of the species. The distinctive features of the named species are uncertain and the extent to which morphology is influenced by host and environmental conditions can not be determined with assurance. Knowlege of life-cycles, intermediate hosts, and developmental stages will be of value in specific diagnosis. Meanwhile, the criteria that have been employed in specific determination are variable, flexible, and must be applied with discretion. The worms are blood-suckers and occur in small, never large numbers. They may live for many months, possibly a year or more, and grow as long as they live. They become gravid at one-third of the maximum size and growth of regions and organs is not constant, but varies with age and size; possibly also with the host. Sucker-ratios, the relative size of oral and acetabular suckers, are significant, but the size of the sucker is dependent on the amount of pressure exerted on the structure during fixation. Egg-size is also significant but young worms, especially, produce eggs of differing sizes. In the initial portion of the uterus the eggs are broadly oval, almost spherical, and the shells are thin, flexible, almost transparent. As they traverse the uterine coils to the posterior end of the body and forward to the metraterm, they become smaller and narrower, the shells contract, thicken and become yellow or brown.

Lintonium pulchrum is very similar to *L. vibex* and the two may be identical, as suspected by Johnston. The studies of Manter and Pritchard established the validity of *L. consors.* The specimens described by Crowcroft (1950), Parukhin and Chicunova (1964), Oshmarin (1965) and Machida (1971) as *L. vibex* and those described by Madhavi (1975) a *L. pseudovibex,* may belong to *L. laymani.* The specimens described by Bilquees (1972) as members of a new genus and transferred to *Lintonium* by Madhavi (1975) probably belong to distinct species and study of additional material should clarify the situation.

Summary

Distomum vibex was described by Linton (1900) from *Spheroides maculatus* at Woods Hole, Massachusetts; the species was named type of a new genus, *Lintonium,* by Stunkard and Nigrelli (1930). Sporocysts and cercariae were described and the life-cycle was postulated by Martin (1945); further detailed descriptions of the sporocysts and cercariae were provided by Cable (1954), and a report of the life-cycle is given in the present paper. Other species, assigned to the genus *Lintonium,* have been described from the Sea of Japan, the South China Sea, Tasmania, Australia, Ceylon, the Bay of Bengal, West Pakistan, Hawaii, and the Gulf of California on the west Coast of Mexico. Published accounts are reviewed, but possible influence of development in different hosts can not be assessed with confidence and criteria for specific determination are uncertain. When information on life-cycles and intermediate hosts becomes available, taxonomic decisions can be made with more assurance.

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